

Human Recognition by Pattern of Running

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Background. In the modern world, individuals can be identified through various biometric parameters such as facial features, fingerprints, or retinal patterns. While these methods offer high accuracy, they are not always practical due to certain limitations—most notably, the need for the subject's cooperation during data collection. An alternative method of identification involves analyzing unique physical or behavioral characteristics, particularly gait recognition. Gait analysis presents several advantages: it can be observed from a distance and is difficult to disguise. Most current approaches are statistical in nature and focus solely on walking. However, by examining leg movements, we demonstrate that it is also possible to identify individuals while running [1].

According to biomechanics, walking and running differ in parameters such as step length, step duration, speed, and the amplitude of limb movements. Nevertheless, both are rhythmic forms of human motion, characterized by coordinated oscillatory movements and bilateral symmetry with a phase shift of half a period (fig. 1).

Aim. To identify features that can be used to recognize individuals based on their running patterns.

Methods. To analyze human pose over time, we used motion capture technologies, which encompass various systems and techniques for digitally recording the trajectories of moving objects or human bodies. With advancements in artificial intelligence and machine learning, human pose estimation from video input is commonly performed using convolutional neural networks (CNNs), which identify individuals and locate their key points in each frame [2, 3].

There are two primary approaches to 2D human pose estimation: top-down and bottom-up. In this study, we employed the bottom-up approach, which begins by detecting key body points and subsequently connecting them to form a skeletal model. This method is implemented in the MediaPipe framework [4–6], which is highly effective in detecting human movement under various conditions and from multiple viewing angles—a significant advantage for our research.

We collected a dataset of video clips, each featuring a single individual taking more than three running steps. These materials were sourced from open-access platforms such as Freepik.com and Vecteezy.com. Each video was then divided into individual frames.

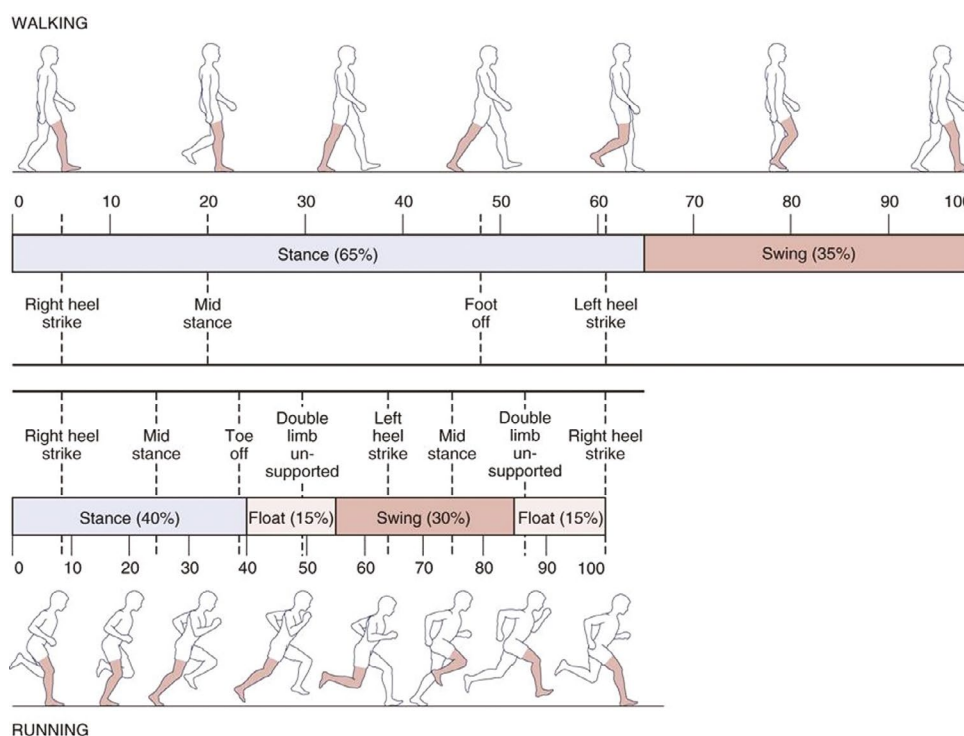


Fig. 1. Walking and running steps

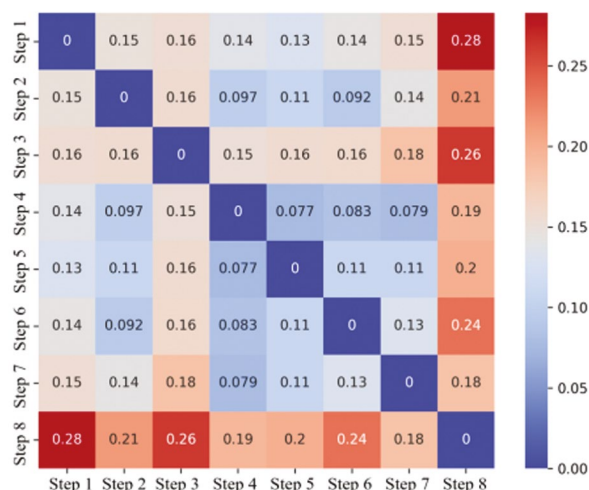


Fig. 2. Similarity matrix between steps (metric RMSE)

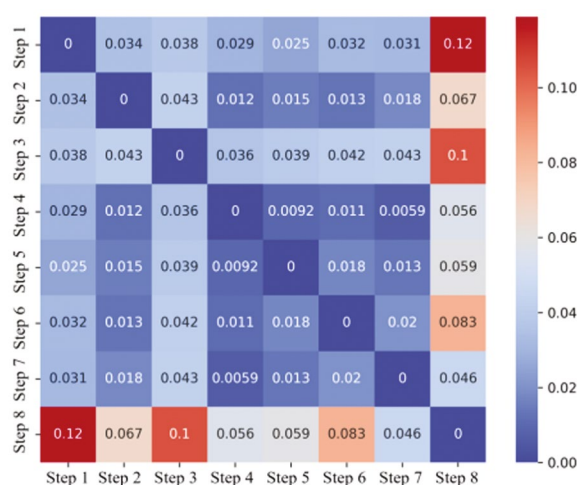


Fig. 3. Similarity matrix between steps (metric cosine distance)

Person detection in each frame was performed using a custom Python program based on the MediaPipe framework. This process yielded a dataset of 3D coordinates for each body key point. The data were normalized, and the center of mass for each subject was calculated. Limb coordinates were then recalculated relative to the center of mass, and the data were smoothed using the Savitzky–Golay filter.

In our research, a step is defined as the motion of the ankle joint relative to the hip, measured over a specific time interval. To enable meaningful comparisons between steps, we interpolated the data to standardize step duration. We then calculated the average of all steps to define a reference step. Each step was compared to this reference using two metrics: Root Mean Square Error (RMSE) and cosine distance.

Results. Figures 2 and 3 display the RMSE and cosine distance values obtained during the experiment using the parameter `static_image_mode=False`, which preserves the continuity of poses across consecutive frames.

Conclusions. The results confirm the effectiveness of the proposed method. We observed significant similarities between individual running steps. Low RMSE values indicate that the model accurately captures the characteristics of running movements, while the cosine distance values demonstrate strong consistency between analyzed steps.

Keywords: gait recognition; neural networks; human identification; MediaPipe; human pose estimation.

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